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ABSTRACT

This paper outlines assumptions and principles related to computer mediated learning (CML) and suggests instructional design and classroom strategies for CML planning and practice. The pedagogy of control is contrasted with the pedagogy of choice and the latter constructivist viewpoint is recommended as the basis of CML. Assumptions about learning in the pedagogy of choice are explained, including reality as a mental construction, disequilibrium leading to learning, learners' construction of learning, transformation of information through construction, self-construction versus social construction, and differential time needs. Instructional design practices in CML are outlined: (1) constructivist planning practices that foster student development (instruction in realistic settings, using existing knowledge, learning as ongoing conversation, time for reflection and guided practice, flow charts to show multiple tracks, just-in-time learning and design, field-testing materials); (2) cognitive practices related to rules and norms, student self-regulation, reflective procedural knowledge, personalized learning, self-assessment/analysis, use of concept maps, collaborative research, idea generation, coaching, problem-based practice, and different designs for novices and experts; (3) affective and motivational environments (psychologically secure environment, student empowerment, support for curiosity and intentional learning processes, project ownership, student responsibility, negotiated learning tasks); and (4) instructional design tools (advance organizers, hypertext, play, case studies, authentic learning, think-alouds). Collaborative student learning strategies include sharing perspectives, self-explanation, watching others, peer scaffolding, reciprocal teaching, and sharing ways to structure and remember information. (SV)

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INSTRUCTIONAL DESIGN IN COMPUTER MEDIATED LEARNING*

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INTRODUCTION

There are those who say that the computer is a non-pedagogical entity. That is, that the computer is only a vehicle for the transmission of information. They cite research that shows that there is no difference between learning in CML environments and the traditional classroom, and they are satisfied with their findings. This, they say, shows that CML is not different from face-to-face instruction, and that when CML is more efficient it can be a substitute for traditional classrooms. Others believe that if we let students take charge of most of their learning, the computer will serve as a facilitative medium, things can be done collaboratively on the computer in ways that cannot be duplicated in the traditional classroom, and the computer mediated learning environment is, in fact, pedagogical, and so is its associated technology.

THE PEDAGOGY OF CONTROL VS. THE PEDAGOGY OF CHOICE

Competing Philosophies: There are at least two competing philosophies and concomitant pedagogies which come into play when you look at ways to design materials for use in Computer Mediated Learning (CML). See http://www.cet.sfsu.edu/moving-courses/teachinh.html or http://www-distance.syr.edu/human.html.

The Pedagogy of Control: The pedagogy of control assumes that those who have the control determine the sequence in which the learner approaches the material to be learned and the pacing at which that material is presented. The teacher determines what the content is that will be presented (see for example http://icg.harvard.edu/~chaucer/pronun_3.0/pr.html). The student is given little or no choice over what is to be learned or the sequence of learning. Teachers have authority and they are in control.

The Pedagogy of Choice: Within the pedagogy of choice, knowledge is assumed to be socially constructed. The typical learning experience is collaborative and cooperative so that social interaction can take place. The focus is on the interaction between the learners trying to develop a solution to an authentic problem rather than responding only to teacher directed/created information. Learning is more open and dialogic (see http://www-csc195.indiana.edu/csc195/wiburg.html). This has also been framed as the difference between instructivism and constructivism. We will take a constructivist viewpoint in this paper.

ASSUMPTIONS ABOUT LEARNING IN THE PEDAGOGY OF CHOICE (see http://ouray.cudenver.edu/~jlteslow/idfund.html)

Reality Is a Mental Construction: When a person sees something he/she relates it to what is already known, and evaluates it in terms of interest, possible danger, the possibility of eating or being eaten, etc. Each person sees a somewhat different environment even if they are beside one another and look at the same things. What we behold is a function of what we know; we can only interpret what we see on the basis of what we know.

Disequilibrium Leads to Learning (Change in Schemata): The way in which a learner learns is to be placed in a situation in which his/her cognitive structure is inadequate to understand or to operate in the environment. The learner is imbalanced and cannot proceed without making a change in the way that environmental data are perceived and knowledge is constructed. To reach new understanding, a change in schema structure is necessary. Growth of knowledge is sparked by feedback from questions, contradictions, experience, and cognitive reorganizations.

Learners Construct What They Learn: The pedagogy of choice assumes that learners construct their own learning. Learners acquire information and transform it based on what they already know and have experienced. They are active learners, and anything they are not active with is unlikely to be learned. Each learner has a discourse history which is based on the previous experiences. All new learning is based on previous learnings. In constructive learning, the assumption is that the learners, with some direction/facilitation from the teacher, will know what is good for them. Learners are capable of acting on this knowledge and will do what they feel necessary to learn what they feel they need to know. From the teacher's view the students become more accountable, they spend more time on clarifying their own thinking through social interaction, and they respond better to questions since they are usually the ones who pose them.

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*An expanded version of this paper and its corresponding presentation are available at http://home.okstate.edu/conference.

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Construction Transforms Information: When information is constructed into knowledge the information is transformed. The transformation relates the new knowledge to the existing knowledge using all of the knowledge which the learner associates with the new knowledge. Hence, individual schema and schema components are different, and each individual has a somewhat different perspective on what is learned than do peers and the teacher. The learner's psychological past (success, failure, motivation, interest) tempers the way in which learning is approached.

Two Methods of Construction - Self-Construction and Social Construction: Piaget describes individual or self construction as the way in which children come to know and understand. Vygotsky (1978) uses social construction and focuses on what learners learn from others, emphasizing the social aspects of learning (see http://www.gsu.edu/~wwwitr/docs/social/index.html). Both are correct. Much knowledge is constructed in social environments where people interact and all learn from the process. When social knowledge is to be learned it is best learned in a social environment through interaction. This interaction involving peers and teacher is normally discussion and inquiry based one or more learners interact to find out about something. For this reason CML should normally be collaborative.

Differential Time Needs: Whether you use a synchronous or an asynchronous approach to CML, you will have to take the students' differential time needs into account. In real time (synchronous), learners will have different reading and writing speeds, and some will type better than others. This will affect the way in which they can interact. Learners will reflect on information and transform it into knowledge at different rates. If adequate reflection time is not provided, some students will not transform the information into knowledge. In asynchronous environments, some learners will have more time to be online than others. They will have personal obligations, like family, which will distract them. You need to make your expectations clear as to how much logon time is needed and how often it must happen if individual learners are to be adequate collaborators in a course. Finally there is machine time. Not all learners will have equal access to a computer at all times of the day and night. Some may have access at work or school, and others only at home. Servers may not always be up. You need to explore access to machine time with new learners and insure that they have sufficient access.

INSTRUCTIONAL DESIGN PRACTICES IN COMPUTER MEDIATE LEARNING

In the constructivist process the learner is, to a great extent, in control of the learning and the teacher is the facilitator who tries to arrange the environment in such a way that the learner can proceed through the learning with as few problems and hesitations as is possible. The teacher can only facilitate the learning that the learner wants to attempt, although suggestions and alternatives can be posed which will help guide the learner into sequences which are facilitative from the view of the teacher. Some of the teacher's functions include making disciplinary knowledge visible, showing learners the links between ideas, showing students how to compare alternatives, and critiquing progress. One of the long term goals is to make the learner self-reliant. The learner eventually should be able to function without any teacher scaffolding or support.

Planning Practices Which Foster Student Development from a Constructivist Perspective

Anchor Instruction in Realistic Settings: Constructivist instruction/facilitation is best when anchored in realistic settings. Learners are more motivated to learn when their learning allows them to work on authentic problems and in settings which are real. Real audiences are provided in CML settings by having learners products displayed on the Internet, advertising the site so that others will visit it, using products for other learners, and developing additions to the discipline home page.

Use Existing Knowledge: Encourage maximum use and examination of existing learner knowledge. You may want to follow traditional design procedure here and remind learners of what they already know so as to facilitate recall of previously learned knowledge. Try to lead participants into learnings which use what they already know in addition to new information to solve real problems. Learners have many resources which they usually do not use. They have been trained in traditional education to wait for the teacher and that the teacher will provide. This usually leads to shallow and surface learning. Deeper learning comes when the learner reflects upon what he/she knows and uses that information to solve problems or to create products. This is the kind of process that should be fostered in collaborative learning.

Promote Learning as an Ongoing Conversation: Social constructivism assumes that learning is a social process where learners learn from each other and from the teacher(see http://www.cl.uh.edu/INST5931/Lesson6 /less6.html). Learners talk about what they are doing, learning takes place in an authentic situation, and the learners are interested in solving real world problems. Learning is a social practice which takes place among people while they are in the process of interacting or modeling. The development of learning comes about through webs of

human commitment brought about by webs of conversation. Conversation is an interactive and didactic process based on mutual trust and respect. In a school-based environment, the learning community must provide a psychologically secure environment where it is safe to take risks and easy to trust if collaboration is to be effective. The participants should be sensitive and empathic so that all will be drawn in. More experienced learners guide the less experienced in this learning conversation and the teacher facilitates when needed.

Provide Time for Reflection: Learners need to have time to think about what they are learning. The process of thinking about learning is known as reflection (in constructivism) or metacognition (in information processing theory). Students must be taught to reflect and reflection is useful for deepening the level at which learners know content. Students must think about what they learn in order to integrate it into what they already know. It is a necessary component of constructivism.

Provide Time for Guided Practice: Learners must be given time and opportunity for interactive practice. No learner can gain confidence about ability to perform without being able to use the skills and processes being learned. Practice allows the teacher to provide scaffolding if it is needed and to provide reteaching if the process is completed incorrectly. In collaborative settings practice should be interactive.

Use Flow Charts to Show (Alternative) Structure (Multiple Tracks): Flow charts are useful in showing alternative tracks or paths through the content. In a CML setting, different learners with different learning histories and interests may progress differentially through content. One of the ways the teacher can influence the progression of learners is to provide suggested alternative tracks. Learners will create their own tracks through CML content, if likely looking tracks are not provided. The alternative track flowchart provides a way to provide guidance while giving the student choice.

Create Just-In-Time Learning: Just-in-time learning refers to learning which is provide just when it is needed to do something or complete some process. Learning provided in this way has a high level of motivation for the learner as its lack will impede the acquisition or performance of the learner. When the learner is developing a track through an individually chosen course of instruction, just-in-time learning is what is needed to provide the prerequisites that the learner needs to reach his/her goals (see http://lrs.ed.uiuc.edu/Music-Ed/index.html). This is easily accomplished in a hypertext environment.

Create Just-In-Time Design: Just-in-time design uses the principle of just-in-time learning as part of the CML design process. This can be done by looking at what is needed to perform critical tasks in the learning and listing them in a way that learners who have not mastered the prerequisites can access when they want to perform a higher level task. The usual process is to conduct an abbreviated task analysis of each major content or process area and insure that the major prerequisites have been identified. Then each of these can be programmed as a module which learners can select if needed. Modules will be used for particular learning but should be shared at a variety of levels. For example, a module could be used as a primary method of instruction at one level and as a just-in-time learning at several levels, and as a remedial module for those who have not learned the skills with their first attempt using another format.

Field Test Materials: From the practical design side, you should try your CML materials out before you try them on an entire class, particularly if some of the learners will be at a distance. Page analysis is like frame analysis in the development of instructional programs. You try out each page of content with typical learners and let them read it to see if they can respond correctly. Revise each time there is a problem until several learners have tried it and have had no problems. You will want to plan to use 3-5 learners on your initial run through. If the learners cannot do the tasks when you are there with them, it is certain that many will be unable to do them when they are sitting in front of a computer without teacher support.

Cognitive Practices

Establishing Rules and Norms: Collaborative CML teams need to set rules to insure that all participate and do their part in the collaborative effort.

Set rules collaboratively: Learners should be involved in the development of the rules in a CML environment. The rules should be developed so that the learners are in a psychologically secure environment which allows them to be independent, take risks, and explore without the threat of ridicule or punishment.

Rules reduce conflict: The purpose of having rules is to reduce conflict between the participants. The learners need to set the rules in such a way that all know what they are allowed to do and why. Rules without understandable reasons are the first broken. Learners will not attack each other if they have set rules against it. Rules, at least in a socially constructed environment, are the grease that allows interaction to work smoothly at a distance. According to Ostrom (1990), each collaborative group creates and implements a set of rules. The teacher can facilitate by sharing what other collaboratives have done in the past so that the group does not have to reinvent

the wheel. First of all, the boundaries of appropriate interaction need to be clearly defined. There needs to be low-cost conflict resolution mechanisms. The community must monitor the community. Individuals can modify the rules as long as the rights of others are respected by the authorities and the participants.

Teach Self-Regulation: Try to increase student awareness of their own self-regulation of behavior. The student must believe that he/she is incharge of his/her personal learning and behavior. With some learners self-monitoring behavior may have to be taught. Teach monitoring strategies like checking their work in mathematics. Provide strategies that provide them time to reflect on their behavior. Learners should always look at what they are doing as part of the learning process. Provide modeling or mentoring in attention control. Teach journaling, or recording of what they are doing/thinking while they are in contact with the information to be learned. This may help in identifying problems. Self-regulation is teachable.

Losing Self-Regulation: All children start as self-regulated learners. Sand box takes no instruction, other than for safety (don't throw sand). It is only later, after they have had less than optimal experiences in school, that they fail to try. Learners do not try because they have failed. They do not try because they cannot predict that they will have success. The rationale is "Why should I expend effort when I can't see any possibility of a reward or a win at the end of the effort?" To help learners become self-regulating again, we need to allow success, allow participant choice (because they are much more likely to predict success if they can choose among tasks), track control, and have participants reflect upon their learning. They should be stimulated to think about how they achieved success. Is it when they have control? If it is, then providing more control to them should facilitate their learning, and it should help them to see that they can self-regulate.

Promote Reflective Procedural Knowledge: To promote reflective procedural knowledge the learner must not only do the task until he/she has automatized the procedure, but he/she must also think about the procedure and why the steps are taken in the sequence used. However, just thinking about the process is not always enough. To insure that the process works, and that the learner is thinking about all of the steps, you should implement a teach-back technique where the learner who knows the process teaches it to a novice who has not previously had instruction. In the process of teaching, unreflected upon steps in the repertory of the expert will become illuminated as the novice struggles to accomplish the task.

Allow Students to Personalize Learning: Each learner, because of a different learning history, will come away from the learning knowing different things. This should be expected and planned. Learners should be encouraged to personalize their learning and tie it to previously learned information and practice (see for example http://iq.orst.edu/philo201/s96/09eth01.html). Personalized learning will be much better remembered than learning which is the same for all and not relevant to some.

Promote Self-Assessment/Analysis: A self-directed learner needs to be able to determine when he/she has learned. This is done through self assessment. This is a skill that many do not have. They have never had an opportunity to practice self assessment. In fact, many do not even know how to set goals since teachers usually set their goals. Learning and self-assessment starts with goal setting and identifying how to determine if goals have been attained. Have learners brainstorm criteria, select criteria and then test/assess themselves to see if the self designated criteria have been met. Practicing this skill will help learners to determine if they have learned and they will develop the ability to generate criteria and see if they can reach them.

Teach Use of Concept Maps: Cognitive maps, sometimes called concept maps, are designed to show an individuals organization and structure of a particular area of knowledge (see http://www.to.twente.nl/user /ism/lanzing/cm_home.htm). The concept map is a method of representing knowledge which assists in the development of schema. The process developed by Novak, represents structural knowledge. Structural knowledge allows learners to understand the relationships between knowing and applying or using. Structural knowledge is necessary for the use of procedural knowledge as it provides linkages between the declarative knowledge and the procedural knowledge. Concept maps provide an integrated network of relationships and linkages between nodes representing declarative and procedural knowledge (see http://www.icbl.hw.ac.uk/~granum /class/altdocs/dav_alt.htm). The cognitive/concept map is theoretically based in both schema theory, from Piaget and Vygotski, and in semantic networking theory. It should be noted that the concept map is different from the mind map in the sense that the mind map is organized around a single concept and the concept/cognitive map uses multiple concepts. Each individual may create a different map of the same content. The extent to which the maps of individuals correspond indicates the relationships between the ideas that they have organized. For this reason, many CML teachers either provide concept maps or they help their participants create them. In the learning setting, the cognitive map can be used to aid in learning by providing a structure into which a learner can integrate new learning with old learning. Cognitive maps assist in knowledge construction through establishing relationships

between knowledge components. If used in a formal way, concept maps specify what concepts have in common and cluster common or related concepts. Learning is facilitated through the establishment of these relationships and by the reflection that takes place as the learner contemplates where to put new information in the existing structure. In a sense the cognitive map is a way for the learner to formalize the construction of new knowledge in a way that is visible to others. This is important when others are to assess the learner's understanding or to diagnose undergeneralization, overgeneralization and misconception. Cognitive maps are useful in communicating complex ideas and in solving problems, particularly those which involve relationships.

Involve All Collaborative Groups in Research: Having a research focus (through data gathering or through text research) provides a focus for learning, and, if the research is learner interest driven, it will create high levels of motivation and interactive participation. Typically we set up research teams of four to ten members, including the teacher or an advanced learner, or a mentor who can function as a facilitator and resource provider/finder. Research teams draw on the expertise of all members, may recruit additional members or solicit external experts, and complete a research based product that goes to a real audience rather than a contrived one.

Promote Idea Generation: Idea generation is fostered through interactive brainstorming. Idea linking can be fostered through seeing others make associations with which a learner is not familiar. In this case, the learner can discuss the association with others to see if it is acceptable to his/her cognitive structure. CML also fosters the development of idea structures which are both hierarchical and sequential. These mutually agreed upon structures form the basis for the development of mutual understanding and the development of a community of learners with a common conceptual base. This concept is clearly seen in Usenet applications where interested learners share information and come to conclusions about a great variety of topics. Usenet is a constructivist process by definition.

Provide Coaching: Part of the collaborative process is the scaffolding that is provided through coaching. Coaches (peer or teacher) help participants elaborate on knowledge and seek understanding and a fullness of meaning. Coaches collaborate with learners to develop solutions in a iterative and recursive process. Coaching should be provided when the learners needs it. The just-in-time idea focuses on the learner and empowers the learner to explore information until the learner feels a need for instruction. This is a time of high motivation where the learner really wants to acquire the information which will lead to goal accomplishment. Instruction should therefore be provided when the learner asks for it. It should be remembered that the learner can also learn from failure and the coach should not try to insure that the learner is always successful. Learners should be encouraged to record and report failure so that they and others can learn from it in a safe environment.

Promote Problem Based Practice: Real problems are the meat of constructivist learning. Promote problem based practice using authentic problems which are selected by and of interest to the learners (for an example from physics see http://weber.u.washington.edu/~augraf/diagnoser/diagnoser.html).

Use Different Designs for Novices and Experts: Different from traditional design theory, constructivist design assumes that experts learn in a different way from novices. The novice does not understand the terminology, the assumptions, the ethics, and the practice of the discipline. These all need to be taught or at least controlled before the learner can solve authentic problems (see for example http://www.unc.edu/courses/nurs117/). The expert, on the other hand, can proceed with only a new piece of knowledge and apply that knowledge using the well known disciplinary framework for problem solving. The novice therefore must get qualitatitively and quantitatively different instruction and may have to perform in alternative authentic environments to be successful and not in danger.

Affective/Motivational Practices (see http://www.soc.hawaii.edu/~leonj/leonj/leonpsy /cognitive.html)

Develop Psychologically Secure Environments: Many feel insecure in learning situations. Participants feel secure when the environment is safe, that is, when they have access to the rewards of learning without threat of humiliation, excessive challenge, or other physical or psychological violence. The CML environment removes the threat of physical violence but it must be carefully crafted to eliminate psychological violence either by teachers or peers. The purpose of a psychologically secure environment is to reduce fear, decrease feelings of dependency and conditional acceptance, and to promote learning. If this is done, learner risk-taking, independence, motivation, and creativity will be improved. In addition, there will be an increase in both social and academic interaction.

Empower Learner Control: When group members are new to collaborative CML learning they will typically want to defer to the teacher as the authority figure. They will want to ask questions and have the teacher be the font of all knowledge. This should be avoided when possible. Remember that unless you build it in, there will be little student control. You will almost always want to refer learner questions to other learners in order to foster dialogue. Questions should be redirected to the group. This can be done gently by sending a message to all

in the vein of, "John has asked a very interesting question,--------. What do you think of it and how would you suggest that he go about resolving it? Please share your responses with all group members."

Support Curiosity about Content: Curiosity promotes exploratory behavior. Learners who are curious will want to investigate and to try to find out about the object of their curiosity. Teachers should nurture the learners natural curiosity by presenting controversial material, using advanced organizers, or by illustrating incongruous findings or events. Curiosity will be facilitated by using primary source data related to real problems in which the students are interested. Teachers should use open ended questions that have the potential for multiple correct answers. Open ended questions promote contradictions that foster discussion and promote the development of metaphor as part of explanation. When using open ended questions teachers must provide time for the learner to construct a response. This is one reason why asynchronous formats may increase constructive learning. Ideally, learners will be curious about all content they might contact. In reality they will only be curious about some of it. When students evidence curiosity, teachers should support and foster it as it improves motivation and concomitant learning.

Support Intentional Learning Processes: Lebow (1993) argues that constructivists should support intentional learning processes. The learner has responsibility for learning, but the teacher should embed reasons for learning in the CML itself. This will support the internal motivation of the learner. The teacher should try to provide a learning climate that supports autonomy and relatedness.

Distribute Project Ownership: One of the practices which will help learners collaborate is distributed project ownership. All team members in a collaborative team should be interested in the project, discussion, experiment, or research in which the team is involved. Each learner or pair of learners should have a piece of the project to accomplish based on his/her level of expertise and interest. This distributes the ownership of the project, gets everyone involved, and keeps people interacting if they are to share what they are in the process of creating.

Give More Responsibility: Participants are responsible for contributing to the learning of others, for collaborating, for reflecting, and for providing knowledge which they have already acquired. Learners are also responsible for scaffolding with other learners, sharing knowledge structures and the like. The learners should be reminded of this periodically.

Negotiate for Learning Tasks: In collaborative settings, as in all constructive settings, learners negotiate for learning tasks that fit their needs or interests. Learners dialogue with others, the teacher, and with materials. Learners expand on or adapt materials to build cognitive structures and to extend their discourse histories. Using teachers as a resource, learners can conduct just-in-time research on the Web. What we mean here is that when questions are asked in a collaborative setting, individuals, with teacher assistance at the start, can seek information to answer the questions on the Web. Use of the Web enhances learner autonomy because the learner controls the searches and personally integrates the search results. In a CML environment, teachers should try to make the implicit explicit, show strategies that differentiate the novice from the expert, and show learners how to find appropriate resources on the Web. When the learner controls the searching, instruction supports construction.

Tools in Instructional Design

Give Priority to Knowledge Construction: Priority should be given to knowledge construction. Knowledge is constructed when new information is interpreted and integrated into old schema in memory or when new schema are developed and interpreted through the previous knowledge of the learner. By showing learners the relationships between old and new information and by having the learners use the information in ways that lead them to solve problems, they will construct knowledge when they use information in ways which are meaningful to them. The knowing (understanding) of these relationships cannot be teacher imposed unless the learners are in a sequence leading to participant selected goals.

Develop Advance Organizers: Advance organizers allow learners to select appropriate instruction from a choice menu. Allowing the learner to become an informed decision maker. To accomplish this the advance organizer should show the content and difficulty level of the module to which it is attached.

Use outlines to communicate structure of content: One way to show learners the structure of content is to use an outline. Outlines are most effective when the content is linear and sequential and there are few branched relationships in the content.

Show structural relationships: Cognitive maps (concept maps) are designed to show an individual's organization and structure of a particular area of knowledge. The cognitive map is a graphic method of representing knowledge which assists in the development of schema. The mapping process represents structural knowledge (see http://iatl.fullerton.edu/grporganize.htm). Structural knowledge allows learners to understand the relationships between knowing and applying or using. Structural knowledge is necessary for the use of procedural knowledge as

it provides linkages between the declarative knowledge and the procedural knowledge. Cognitive maps provide an integrated network of relationships and linkages between nodes representing declarative and procedural knowledge.

Promote Hypertext for Broadening and Deepening: If you want learners to be able to go through textual material you should provide them with an opportunity to go farther into the content than the typical linear text. This can be accomplished through the use of hypertext (see http://www.ils.nwu.edu/~e_for_e/index.html). Hypertext has links for expansion (broadening) which link to other materials which are beyond the text but which are related, but on the same level. Hypertext can also be designed to allow learners to go deeper into the content by providing definitions for terms, expansion on embedded concepts, and further explorations in line with the text content. This allows learners to go deeper into the content.

Promote Play as Part of Instructional Design: Play is regarded as integral to learning by many constructivists. Play has the following attributes: It is usually voluntary, it is intrinsically motivated, it requires active engagement. There is some make believe quality about it. Work is play if the work is extremely satisfying. When we learn we play if we have not been coerced into learning and we are highly interested in the material or processes to be learned. Play-like environments in CML include games, simulations, virtual interaction spaces, etc. (For play on the computer see http://www.gsu.edu/~wwwitr/docs/mjgames/index.html)

Use Case Studies: Cognitive flexibility theory (Jacobson and Spiro, 1992) asserts that teachers should teach using cases and rich examples. Case studies present a structured case which describes a person, process, company, setting, or the like (see http://curry.edschool.Virginia.EDU/go/capetown/intro.html). Participants analyze the case based on information provided and on case analysis in light of the content that they are learning in the discipline (see http://www.hbsp.harvard.edu/frames/groups/cases/index.html). Students share responses and scaffold each other. The teacher focuses the direction of the dialogue to bring out the desired responses.

Cases as Authentic Learning: Teaching using cases makes the learning more authentic and practical. Edelson, et al. (1995) present methods for scaffolding using multiple case studies in a CML environment. The learners see the case as representing a real world situation and therefore they find the setting for problem solving to be authentic (in teacher education see http://www-csc195.indiana.edu/csc195 /zhao.html). When new information is introduced, links can be made from the case examples to the abstract concepts so that the information can be concretized and presented in a way that the learners can use to tie the new and abstract learnings to their previous knowledge. Because of the rich problem solving context, the instructor can provide multiple forms of information representation trying to find one which will fit with the cognitive structure of each individual learner. All can see how the particular information can be used for their purposes. You should not simplify presentations. You should use cases and complex material as part of the teaching practice. Cases are particularly important when knowledge is anecdotal, experiential, unstructured and nontextual. Provide data on real situations which learners can use to develop solutions to practical problems.

Teach Think Alouds: Consider think alouds if the students have difficulty. In a think aloud, the model describes the thinking process as well as showing the actions necessary to complete the task. The instructor can do think alouds in a CML environment by describing how he/she is thinking about a process as he/she describes the process to the students. When students think aloud, others can follow and learn or provide scaffolding, if needed.

ENCOURAGE STUDENT LEARNING STRATEGIES

Share Perspectives in Learning: Learning is distributed among individuals. Teaching and learning are aspects of the same social process. Different perspectives are arrived at by different learners. Diversity accounts for these multiple constructs. When learners share perspectives in a collaborative way and reflect on the perspectives of others, greater learning takes place.

Learn Through Self-Explanation: Encourage learners to try to explain to peers what they do not understand. In collaboration we talk about what we know and elaborate on what we learn. Collaboration in CML promotes learning through self explanation (you never really understand something until you try to teach it), internalization (learning by talking about it), and appropriation (this is the apprenticeship or the adoption model: you do what I do and you learn how to do it) when working with a more skilled partner or group. Self explanation proceduralizes declarative knowledge during the process of peer tutoring or reciprocal teaching. Learners provide scaffolding for others as they describe the cognitive activity which they use in building an explanation.

Learn from Watching Others: Encourage learners to observe what others do. The presence of colleagues extends one's own abilities according to Vygotsky (1978). We monitor our progress by observing what others do or are capable of doing. This validates what we do, provides a perspective on progress, and provides scaffolding, if we are not as far along as some of our peers. Having colleagues also helps us to articulate prior knowledge through the sharing process as we discuss what we know. This Vygotskian process--internalization--

requires active participation of all participants.

Provide Scaffolding for Peers: When peers ask for assistance or when team members discover that a member has a misconception, peer scaffolding should be offered. This requires a psychologically secure environment, but, when the process has been established, most will find that peer scaffolding is better than teacher scaffolding. The rationale here is that the examples and processes presented are more likely to be on the level of the learner when they are provided by a peer who is not as sophisticated as the teacher in terms of the content. In a psychologically safe environment, the teacher may be the first resource used for scaffolding until students seek help from others. After collaborative groups have been working together for a while, there will be little need for external scaffolding from the teacher unless they cannot scaffold each other and their own internal resources have been exhausted. If teachers do too much scaffolding, much of the value of the collaborative experience designed to help them work together solving authentic problems, will be lost.

Encourage Reciprocal Teaching: Here each learner helps other learners by teaching what he/she knows. There is a shared problem context where all learners know the problem that they are trying to solve. They provide each other reciprocal scaffolding as all take turns teaching the group. In some cases, this may be as simple as reading something (possibly from a reading list) that others have not read. Then the reader can lead the discussion on the new information and teach his/her peers. In this way learners are both producers and critics of the work in progress and they learn self monitoring in the process. Learners share meanings, they share necessary information which with transformation turns into knowledge, and they share conceptualizations and conclusions. They have a division of labor by pooling the different roles and talents needed to solve the problem.

Share How They Remember Information: One of the things that collaborative learners can do to facilitate each other's learning is to share how they remember information. This relates to the ways in which they have constructed their knowledge. Sharing these strategies shows other team members alternative ways to look at information and alternative ways in which to structure the knowledge. This should improve recall as it provides additional ways in which to access the information. Learners should be encouraged to talk about knowledge organization and to share strategies for learning information.

SUMMARY

CML should be based in a pedagogy of choice. Choice reinforces constructivist principles and helps the learner control and understand the information to be transformed into knowledge. Instructional design should be rooted in authentic learning using a social constructivist viewpoint. Learning should be provided relation to cognitive, affective and actional components. Learning best takes place in psychologically secure environments where learners are able and unafraid to try and to succeed with challenging learning related to their interests. A number of tools are recommended including case studies, advance organizers and hypertext. Students should be encouraged to facilitate each other and provide scaffolding and modeling in collaborative settings

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